The Benefits of Regulating Hazardous Waste Disposal:
Land Values as an Estimator
VOLUME I

by

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I.   INTRODUCTION

Cost-benefit analysis of environmental regulations and, more generally, the determination of the nature of desirable regulations require the estimation of their potential and actual benefits.

In the regulation of hazardous waste disposal, two generic policy issues have surfaced:

1. Existing disposal sites may pose threats to human health and welfare. What level of remedial action or compensation to the victims is appropriate?

2. New facilities create a disamenity when located in or near an urban area. What types of controls should be used to avoid undesirable risks to health and welfare and what payment is needed to compensate nearby property owners for the disamenities associated with the facility?

These questions involve one common theme: the need to measure the benefits of reduced risk from the more careful disposal of hazardous waste, or, in other words, the damages from exposure to the risks of hazardous waste disposal. The negative value (costs) of a disamenity are typically difficult to measure, because there is no market for most reductions in disamenities. Consequently, indirect methods of measurement must frequently be used.

Economists have identified several distinct conceptual approaches that, in principle, could be used to measure the relevant benefit or damage functions for non-market commodities such as health and environmental risks. One method is to measure current and anticipated physical damages and then place appropriate economic values on these effects. A second

is to survey individuals directly concerning the amounts they would pay

to reduce risk or the compensation they would demand to bear the risk of

proximity to a disamenity. A third approach is to analyze voting behavior

when decisions such as hazardous waste siting are subject to a referendum.

A fourth method uses prices in related markets to infer the values

individuals attach to non-market goods and services.

All these methods have disadvantages as well as advantages. Placing

monetary values on risks to health and life defies satisfactory solution;

there is no market in which reduced risks are bought and sold. Although

medical costs and other resource costs can be used to estimate lower

bounds, and a human-capital approach may reflect earning power lost, neither

captures the distress and suffering associated with actual illness or

premature death. Further, assigning pecuniary values is morally repugnant

to some analysts and policymakers. Resorting to even sophisticated

questionnaire techniques can not avoid all the problems of the inherently

subjective nature of responses to hypothetical questions. As has been

shown by Bishop and Heberlein,[1] there may be large differences between

the amount at which people say they value a thing and the amount they are

willing to take for it. The problems with interpreting referenda are

both that they are few and that the voters must vote for or against a

proposal, not indicate how much they value their support for, or their

opposition to, a waste dump.

In this study we are concerned with the last approach--the use of

differences in property values--to estimate the value individuals place

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[1]Richard Bishop and Thomas Heberlein, "Measuring Values of Extramarket Goods: Are Indirect Measures Biased?," American Journal of Agricultural Economics, (December 1979): 926-30.

on the disamenities associated with proximity to a disposal site. Each
approach has its own strengths and weaknesses. The property-value approach
is particularly attractive for a number of reasons:

o The basic objective of all methods of ascertaining the economic
welfare losses associated with a disamenity is to determine
willingness to pay for removal of or reduction in the disamenity
or, its near equivalent, willingness to be compensated. Property
values are objective historical data showing what people were, in
fact, willing to pay for property embodying many characteristics,
including its associated amenities and disamenities.

o In light of the fact that real property is immobile, differences
in property values adjusted for factors other than proximity to
a waste site should reflect the cost to property owners of the
disamenity.

o The method has been successfully used in evaluating locational
disamenities other than dump sites.

o The econometric techniques for isolating the impact of disamenities
are available and tested.

o The theoretical basis for the isolation of the price effects of a
disamenity and for relating observed price differentials to changes
in economic welfare is available, as discussed in Chapter II.

o Although any estimate of welfare loss based solely on property
value impacts is only an approximation, it may be possible to
identify and to measure, in many instances, major components of
over or underestimation.

The property-value method is based on the observation that the value
of each piece of residential real estate (lot, developable set of lots,

existing house with its lot) depends on the utility derived from housing presently or potentially located on it. The utility of a particular house is a function of a multiplicity of characteristics. If a given characteristic is significant and equally significant to all present and potential owners of houses in a real estate market, a widely perceived change in that characteristic will alter each market participant's evaluation of real estate in the affected area by the same amount.

The simple application of the property-value method implies the following:

1. Proper adjustment has been made for amelioration of effects. Amelioration reduces private loss and is not reflected in the price of real estate in the affected area.[2]

    Should the hazard be ameliorated at public expense, the cost of amelioration should be added to the cost determined from price differentials.

2. In the real estate market in the affected area all participants, owners and prospective buyers, are fully informed of the hazards and other adverse aspects of the waste dump. There is an asymmetry regarding information and its interpretation. If market participants accurately interpret described risks as posing more danger than they objectively do, they may discount the value of affected property more than they objectively "should." However, the perceived risks of individuals constitute a genuine loss in the utility to them of living in the affected area. (To believe

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[2]For ease of exposition, we speak of affected "areas" or "zones." In fact, impacts of the site presumably decline continuously with distance from it, and this is taken into account in the more detailed discussions below.

otherwise would imply that there is no economic cost to malicious
rumors that affect property values.) Therefore, a reduction in
property values based on such psychological overreaction is
appropriately included in computing potential benefits of regu-
lation. In contrast, should market participants underestimate
the severity of the hazard and not discount the property as
much as they "should," the use of property values would under-
estimate the social loss, because present or future owners
would ultimately discover **that the adverse consequences were**
more than they had anticipated.

3. Similarly, **expectations** are **important. In estimating property**
value effects for an environmental amenity, **it is essential that**
the transaction be free of expectations of the change. That is,
the pre-change sample should be taken before market participants
begin to suspect that a change will ensue.

4. All owners and potential buyers have identical tastes and prefer-
ences with regard to the disamenity and have identical incomes.

Violation of the first three of these conditions leads to understate-
ment of the costs of the disamenity as estimated by the use of differentials
in property values. Hence, if the impacts of **heterogeniety** are small
and if expectations are borne out in the future, estimates of potential
benefits of regulation based on this technique should be understated.

The overall purpose of the present study is to determine both in
theory and practice whether changes in real property values constitute a
valid and useful measure of the costs imposed by a hazardous waste site
on the proximate neighborhood and, hence, of the welfare gains potentially

achievable through regulating the location or characteristics of such sites.

Subordinate purposes are:

o To examine how, in principle, to isolate and measure changes in property values associated with a hazardous waste site;

o To develop and illustrate the application of a suitable methodology for doing so;

o To measure price effects in specific cases and to learn how EPA might undertake such measurement in making regulatory decisions;

o To explore, through the specific case studies, the conditions under which application of the method would and would not be practical.

The specific hypothesis to be tested empirically is: property values are depressed by the presence of a hazardous waste dump.

The PIE-C approach to accomplishing those purposes is rather straight-forward. After a review of the literature and explication of the relevant theory, limitations on and conditions for successful application of the general method are presented (Chapter II and Appendix A).

To isolate the effect of a hazardous waste disposal site on real estate prices, we performed multiple regression analysis using charac-teristics of individual properties as the determinants of price. Dozens of papers have used some form of such a hedonic analysis to isolate the impact of various factors on property **values.**[3] Many of these studies have related price impacts to environmental disamenities, especially air pollution, but also proximity to positive amenities. In most cases, the

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[3]**Appendix** A contains a brief account of the relevant literature.

sit

hypothecated relationship between property values and the presence of an

amenity or disamenity were found to be **consistant** with the empirical results

The method has not been applied previously to evaluate the economic

consequences of hazardous waste disposal sites. Hence, this study, in

addition to being of value to EPA, should constitute a contribution to

the literature of environmental economics.

We developed a cross-section method whose objective is to isolate

the effect of the intensity of the disamenities associated with a dump

on real estate prices. The period of interest was after the "event"--the

institution of a dump or the discovery and publication of the existence

of an old facility or of the fact that it was generating some form of

hazard. In this approach, distance has been used as a proxy for intensity

of exposure.

The alternative of using a time-series analysis of the effect was

explored. Two cross-sectional studies, one before and one after the event,

were performed for one of the sites. Comparing the price differentials

in these cases should provide a check on the accuracy and reliability of

the estimate based on an ex post cross-sectional study. Having found

land value effects in one site, we compared the gradient as a function

of proximity before and after the event.

To test and illustrate the method, two sites (Pleasant Plains, New

Jersey, and Andover, Minnesota) were selected for case studies, after

examination of a large number of potential locations. In each case,

recorded sales prices and recorded housing, neighborhood and socio-economic

characteristics were gathered and incorporated into the multiple regression

analysis.

Actual property sales are preferred over other indicators of capital values affected by proximity to a disamenity. Assessed values, for example, are only useful to the extent that they reflect actual market prices, and owner estimates of value are subject to several possible errors. Observed sale prices can also be used as proxies for the loss of capital values of residential properties in the area that did not change hands, for the potentially developable residential land in the area and, in some cases, for commercial properties in the area. The total cost of the disamenity was calculated both for residential properties and for all real property in the area examined.

II. PROPERTY VALUES AS A MEASURE OF WELFARE EFFECTS

This chapter presents a simplified discussion of the rationale for using property value differentials as a measure of the welfare effect of a hazardous waste facility. It incorporates parts of Appendix A, which provides a more detailed treatment of the underlying economic theory as well as a review of the related literature.

To argue that property values can reflect the economic benefits of varying levels of environmental quality, it is necessary to establish first how environmental quality affects the land market. Land prices for specific parcels should equal the discounted value of the stream of future net benefits attributed to each parcel. Observed market prices reflect transactions among individuals, the transactions resulting from the different values attached to the property by the buyer and the seller. To the extent that environmental quality affects the net benefit stream received from holding a parcel, the value of the parcel to the owner or prospective buyer will rise or fall. For example, an increase in pollution levels in an area, everything else constant, should decrease the net benefits of a residential property, and one would expect that the price for the residence would be lowered.

This relationship can be stated more formally in terms of the utility functions of land market participants. If environmental quality affects the utility derived from purchase or ownership of land, or if environmental quality enters directly in individual utility functions, property values may be affected by environmental change. Either situation is sufficient to ensure that environmental quality appears as a factor in the demand for housing, and, therefore, in the choice of residential location.

If residents and prospective residents indeed do not desire to live near hazardous waste facilities, one would expect that such a facility would have a depressing effect on property values. If a facility is located in or near a residential community, present owners of housing in the affected area may find their property less satisfying than before. Consequently, they may seek to sell it in order to move elsewhere and may be willing to take a lower price than they would have taken before the event.

They may find no buyers at the old, pre-facility, price level, because prospective buyers may also find the facility an unattractive feature of the neighborhood and may correspondingly lower the amounts they would be willing to pay to live there. The consequence is that lower prices would be expected for housing transactions that occur following the siting of a hazardous waste facility in or near an established residential neighborhood. The extent of the price effect should be larger the greater the perceived risk and the more extensive the aesthetic impacts.

Long established waste facilities may also have adverse effects on neighboring property prices. While one would not expect relative prices to be changing as a consequence of proximity to an old facility, unless leaks occurred or other circumstances at the facility change, one might expect to find a stable pattern of depressed prices surrounding the site relative to areas farther away.

A hazardous waste site could affect the value of any property. Residential parcels could be affected through aesthetic and risk dimensions. Commercial property could be affected if a hazardous waste facility influenced the flow of customer traffic or affected the desirability of

the location for employees. Farmland might be affected through related
changes in agricultural productivity or the demand for farm output.
Among these alternative land uses, one would expect the greatest impacts
to occur for residential properties. Other uses simply do not have the
same magnitude of potential aesthetic loss and adverse health effect.
Moreover, as the value of existing housing and other developed property
declines in the affected area, the value of property held for future
development can be expected to decline similarly.

The potential for making objective observations of any property
value effects due to proximity to a hazardous waste site suggests the
possibility of using such price effects to estimate the welfare impacts
of siting new or existing facilities or upgrading the quality of contain-
ment for established facilities. Two steps must be undertaken in order
to measure any such welfare effect on residents. First, assuming that
housing prices are affected by a site, one must isolate the effect of the
facility on housing prices from all other factors that are simultaneously
affecting property values. Second, one must translate the price effects
attributable to the site into measures of the associated loss of economic
welfare. These topics are addressed in turn.

A. Measuring Price Effects

Most recent economic studies of the demand for housing recognize
explicitly and formally the common knowledge that housing is a hetero-
geneous commodity with individual units comprised of bundles of character-
istics such as the number of rooms, style, type of construction, location,
and neighborhood aesthetics. Hazardous waste facilities and other sources
of neighborhood property attributes, thus, enter as elements in the bundle

of characteristics that comprise a housing unit. Prices for individual houses reflect the value that buyers and sellers attach to the separate characteristics. Although buyers and sellers may be mentally adjusting the prices they believe a property is worth to them on the basis of characteristics, such adjustments are not recorded. Rather what is observed is a single price for the entire package of characteristics of a given housing unit.

One possible technique for isolating the effect of individual characteristics on price is to make pair-wise comparisons of nearly identical properties. For example, if one could find pairs of properties that were identical in all respects save for their proximity to a hazardous waste facility, one might interpret the average difference in price as the effect of the waste facility. While such an approach may be theoretically valid, it is not feasible. In practice it will not be possible to find properties that are identical in all respects save for distance to a waste site. In particular, properties that are geographically separate, as two must be for one to be near a waste facility and the other to be distant, will be of unequal distance from other neighborhood features that may affect price.

A far superior approach for holding all factors but one constant, while the effects of that single variable are measured, is a multiple regression analysis. Using data on the prices and characteristics of individual properties in a multiple regression analysis, one may isolate the average effect on sale price for each characteristic. Such a regression of sale prices on house characteristics is termed a "hedonic" equation. The coefficient of a variable such as "distance from a hazardous waste

facility" would then represent the amount, on average, that prices were affected by this variable.

In this context, distance from the site would be, as mentioned in the Introduction, a proxy for the intensity of exposure to the risks from contamination and the aesthetic impact of the site. However, pure linear distance may be a poor indicator of the combined effects of aesthetics and perceived risk. Risk, itself, may be a complex function that reflects several potential pathways for contaminants to reach humans. The potential complexity of risk and aesthetic measures suggest that one may want to consider several specifications other than simply linear distance for any hazardous waste facility variable in a hedonic equation. In addition, other locational amenities and disamenities can be expected to affect price. As distance from the waste site varies, so do distances from these other space-specific amenities. Consequently, problems of collinearity are likely to emerge in the empirical analysis.

B. Measuring Welfare Effects

Assuming that the hedonic analysis described above does find a price effect from a nearby waste site, there remains the issue of inter- preting such an effect in terms of welfare economics. As a preliminary caution, it should be noted that this subject is complex and the reader is referred to Appendix A for further details.
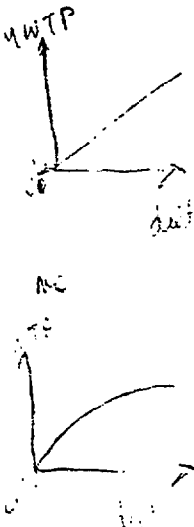
First, it is possible to interpret the regression results directly in terms of the hedonic approach that guided the development of the regression analysis. At the risk of oversimplification, the basic line of reasoning in doing so is that the coefficients of the hedonic equation

are interpreted as the marginal willingness of consumers to pay to acquire

(line omitted)

more of the individual characteristics. Then, to measure benefits, or
changes in welfare from an action such as removing an offending waste
site from a neighborhood, one simply multiplies the indicated marginal
willingness to pay times the average base price of property (the waste
facility is removed entirely) and sums this effect over all affected
houses or all affected units of property. Theoretically, one could
measure the benefits of partial amelioration (less than removal of the
site) by treating degrees of amelioration as being equivalent to some
increase in distance from the actual polluting site.

Converting observed marginal willingness to pay into an estimate
of benefits in this way produces accurate results only if a number of
specific conditions are fulfilled. The marginal willingness to pay must
be constant over the relevant range of values of the intensity of the
disamenity (distance from the dump, in this case). If the marginal value
differs from the value of large discrete changes in the quanitity of a
characteristic, an error is introduced. Also, as mentioned in the
Introduction, inadequate information or its misinterpretation by market
participants can lead to property values that are poor measures of the
actual impacts.

Third, it is necessary that all households be identical in tastes
and income. Thus, they should all have identical demand curves for the
separate characteristics of housing.

Clearly, not all of these assumptions are met in practice. House-
holds are not identical in tastes and income; some are more risk averse
and some have greater distaste for aesthetic insults. Although it would
be desirable to take account of these differences among individuals,

there are no examples in the literature of successful attempts to do so. Consequently, we too find it necessary to use the standard **assumptions.**[4] In addition, the measured marginal willingness to pay may not be constant for large changes in the characteristics. The challenge facing researchers is to select samples and to adjust the regression equations so that the actual welfare loss is closely approximated in the analysis.

    C. An Alternative Analysis of Welfare Effects

        A second and somewhat simpler analysis is available for converting **any observed price differential attributable to** ~~dis~~the **intensity of a disamenity** to impacts on welfare. It derives from a more conventional application of comparative statics to the demand for and supply of real property. Whereas, there is some merit in considering both prospective buyers and present owners of real property as having a demand for that property and combining their offering prices and reservation demand prices into a single demand function, the principles are more readily explained by separating buyers from sellers. For purposes of exposition we begin with the market for housing only.

    In the Figure we draw the _ex ante_ demand curve of prospective buyers as D_0 and the reservation demand curve of present owners as S_0. The curves represent offering and asking prices for housing with a standard mix of characteristics or, alternatively, an average of prices for the actual mix of characteristics. In reality both curves would be rather broad bands, like many market demand and supply curves. The demand curve

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[4]At present, one of the authors intuits that it is possible to demonstrate that the impacts of heterogeneity of tastes can be expected to be relatively small in most practical situations. However, we have been unable to develop a proof of that proposition at this point.

requires no further comment. The supply curve slopes upward on the
presumption that more owners would be willing to sell at high than at
low prices. The curve becomes vertical where quantity equals the existing
number of units, $\overline{Q}$, sold. (The possibility of building more houses does not
greatly affect the analysis, as is mentioned below). In the status quo
ante the equilibrium number of units sold per time period is Q_0 at
price P_0.

If a disamenity is injected into the market, most, if not all, market
participants will reduce the value they place on the property. (If that
were not the case, the "disamenity" would not be a disamenity.) Buyers
will reduce their offering price because the new discounted value of the
stream of satisfactions (utility) they would gain from living in the
area is reduced.

Owners will, similarly, face the prospect of reduced utility and
will redcue the price at which they could be induced to sell. Assuming
all buyers and sellers evaluate the disamenity equally (have homogeneous
tastes in this respect) the demand and supply curves fall by equal
increments, dV in Figure 1. With linear demand curves, there is demonstrably
no loss in consumers surplus; $AP_0 = AP_1$ and Q is unchanged. That this is
the case is obvious from the fact that the new demand price is equal to
the old one reduced by an amount dV that would leave buyers exactly as
well off by purchasing the property at the new price with the disamenity as
they would have been by purchasing it at the old offering price without the
disamenity.

All the social cost of the disamenity is borne by present owners,
and it is borne by all present owners in the affected area, those who

FIGURE 1

Disamenties and Property Values

PRICE

D_0

dV

D_1

P_0 B

P_1 B'

S_0

dV

S_1

S_0, S_1

D_0

D_1

0   Q_0 $\bar{Q}$

NUMBER OF RESIDENTIAL PROPERTIES
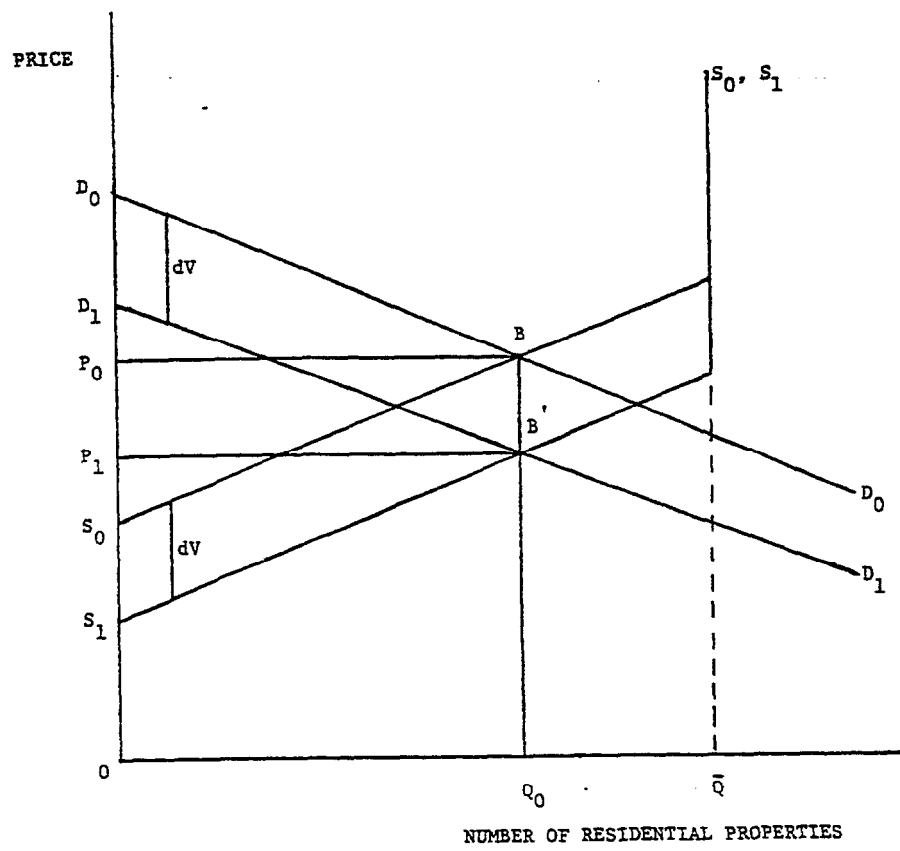
do not sell as well as those who do. This is true because those who sell accept a lower price than would have been necessary before the dump influenced values, and those who do not sell face lower satisfaction from ownership. In both cases, the present value is reduced by the capitalized (negative) value of the disamenity. No significance attaches, incidently, to an analysis of producers' surplus, as that is usually represented diagramatically. The reason for this is that the downward shift in the supply function does not represent a reduction in input of resources but is a one-time capital loss (like that of any other inventory loss).

With dV constant and equal on both sides of the market, output remains constant and $dV = dP$, the change in price. Consequently, the observed price change, as calculated in the regression analysis, represents the welfare loss per unit of real property, and $d\overline{V}\overline{Q}_0$ provides an estimate of the potential benefit of total amelioration.

In order to take account of undeveloped land and the potential for increasing the supply of housing in the affected area, S_0 and S_1 can be considered the horizontal sums of the asking prices of both lots with and without houses. Similarly, the demand curves represent the demand for developed and undeveloped lots. The demand and supply prices of lots without houses are specified to include the cost of adding a newly constructed house of standard or average characteristics.

This interpretation is dependent upon the same assumptions pertaining to homogeneity of tastes, incomes, and to information and expectations as explained in Section B, above.

III. THE SITE SELECTION PROCESS

In the previous section, we presented the conditions necessary for using property value differentials to estimate accurately the welfare losses associated with new or existing hazardous waste sites. These considerations influenced the choice of sites used to measure the effects. In this section we describe briefly our site selection process, including the criteria used to identify and choose sites.

One of the considerations in deriving welfare loss estimates is that tastes and income are assumed identical for all households. To this end, we have chosen sites with populations that are relatively homogeneous with respect to income, race and education.

Further, we selected sites which had large residential populations located in close proximity to a hazardous waste site. Relatively large populations were expected to produce sufficient turnover of residential property to produce a useable data base on transactions. Moreover, only residential properties were selected for the purposes of establishing welfare losses. This was expected to minimize the effect of industrial or commercial ventures which might actually gain from the presence of a hazardous waste facility. The difference between the real estate desires of residential versus commercial or industrial activities can be thought of as presenting extreme differences in preferences. For example, it is possible that proximity to a hazardous waste facility has positive value to some firms.

We attempted to find sites with no other major sources of disamenities in order to facilitate the isolation of the effects of the hazardous waste facilities.

Other criteria for site selection are discussed in Appendix B, but are briefly mentioned here. Information is the most important of these for the generation of price reliable effects. Since land value changes depend on the perceptions of market participants, they should have some knowledge of the existence of the disamenity and some perception of its possible risks.

To some extent, different sites offer opportunities to measure different types of effects. For example, we could use actual contamination of the air or water from a site as an indicator of effect. Alternatively, we could use the physical siting of a facility in a neighborhood. Finally, we could examine the effects of potential contamination.

Using the site selection criteria described **above**[5], we eventually selected, from a universe of approximately 150 potential sites, four sites for data collection. Of these, sufficient observations were available at three, but sufficient usable observations were available at only two. The two sites ultimately selected were in Pleasant Plains, New Jersey, and in Andover, Minnesota, a suburb of **Minneapolis.**[6] The justification for the selection of these sites is presented in Appendix B.

A. <u>Site A</u>

Pleasant Plains is a small community located approximately 3 miles north of Toms River, in Dover Township, Ocean County, and approximately 5 miles west of the Atlantic Coastline. It had a population of 5,600 persons in 1980.

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[5] **A** thorough description of the site selection process is presented in Appendix B.

[6] **Full** descriptions of both sites are presented in Appendix B.

An illegal dumping operation occurred between March and December, 1971,[7] on a former chicken farm in Pleasant Plains. Contamination of the groundwater in the upper of two aquifers in the area occurred as a result of the dumping operation. A physical description of the area in which the dumping operation took place and the site of the dumping are presented in Map 1.

The Pleasant Plains site was chosen for the purpose of this study for several reasons:

- the availability and number of transactions both before and after the episode;

- the magnitude of information on housing characteristics;

- the relatively homogeneous nature of the local housing market;

- public knowledge of the incident within that housing market of Pleasant Plains and its environs--the town of Toms River;

- the recent residential growth in the area, specifically the development of land in the period after contamination was first discovered (Pleasant Plains has been the recent main area of growth of the Toms River region);

- the relative homogeneity of the population (Pleasant Plains may be characterized as having been in the 1970's a desirable white, middle-income community with one-acre lots interspersed with a few farms)[8] and;

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[7]The wastes dumped included aromatic hydrocarbons, benzene, toluene, styrene, xylene, ketones, alcohols and phenolic resins.

[8]It may be argued that the senior citizens' residential community, located inside Pleasant Plains, is a separate housing market. The model was developed to account for any differences.

Map 1

Pleasant Plains
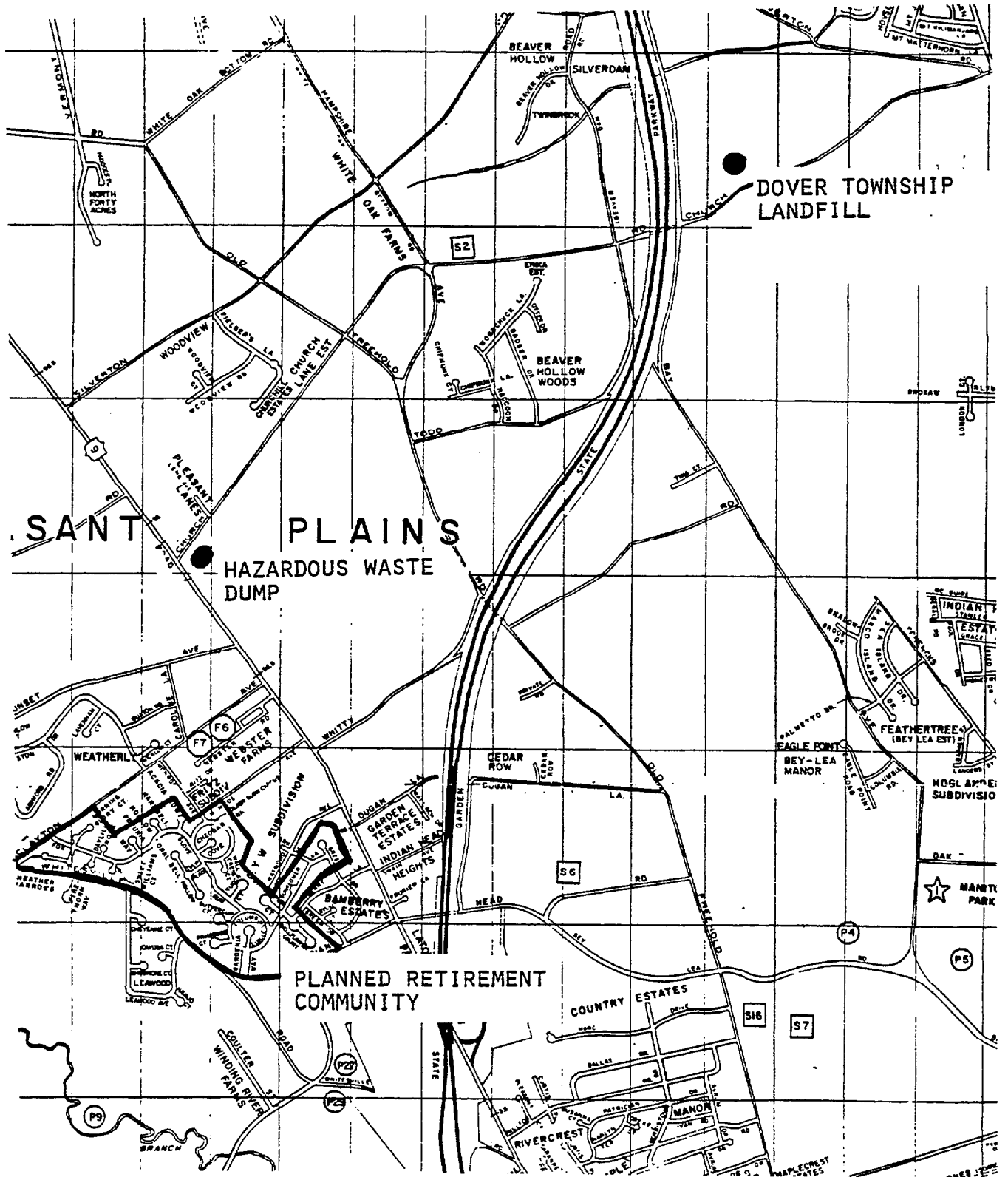
- the essentially residential nature of the area, (there is little
industry and most businesses are involved with services for the
residents of the area).

One would not necessarily expect the price effects from the Pleasant
Plains incident to be large. Local and state officials intervened swiftly
after the first discovery of contamination. They mitigated some of the
threat of further contamination and took responsibility for some of the
costs associated with the **incident.**[9] Clean up of the site was initiated
soon after contamination was first discovered and within a month a
municipal water supply was installed and connected to part of the affected
area. Residents within a mile of the zone were ordered to close their
wells, and those within a zone approximately a 1 to 1 1/2 mile radius from
the contaminated site were ordered to extend their wells into the deeper
(uncontaminated) aquifer. Some of the costs initially borne by private
well users were reimbursed.

Nevertheless, resistance to these measures by residents was signif-
icant, particularly in regard to the capping of their wells. It was
charged that the municipal water was not of equivalent quality to the
contaminated well water, either in terms of taste or in terms of safety.
In addition, those residents who were forced to dig into the deeper
aquifer complained that its taste and smell was much worse than water
from the shallow wells. Hence, besides the quantifiable effect on private
wells resulting from the contamination incident, there is the inherently
unquantifiable perception of increased health risk to local residents.

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[9]**Another** possibly mitigating factor against a strong price effect is the
fact that no contamination has been discovered in Pleasant Plains since
1976.

It should, however, be pointed out that living near a waste site or over a contaminated aquifer may or may not be exposing residents and their progeny to health risks.

Based on these feelings of the residents, there is some reason to expect a property value effect reflecting the loss of use of the preferred private wells and the proximity to a risk of unknown magnitude. Present residents could be expected to value their homes somewhat less because of the deterioration in water quality and possible insecurity about future risks from the site. Consequently, they would presumably be prepared to accept a somewhat lower price for their homes after the discovery of the contamination incident, compared with before. Similarly, everything else being equal, new buyers could have been expected to offer a lower price for a given property. Also, because many of the purchasers of homes in the Pleasant Plains area are from Toms River, they would have been aware of the problems generated by the contamination episode, the quality of the municipal water and, therefore, the meaning of the loss of the use of the upper aquifer. (They used municipal water in Toms River.)

B. <u>Site B</u>

Andover, is a relatively small city situated approximately 20 miles north of Minneapolis, in Anoka County. It is bounded by the cities of Ramsey and Anoka on the west, Coon Rapids on the south, Ham Lake to the west and Oak Grove to the north (see Map 2). The entire area of study has a fairly homogeneous white population with an estimated per capita income in 1977 of $5,658.[10] Andover, in 1981, had a population of 9,520.[11]
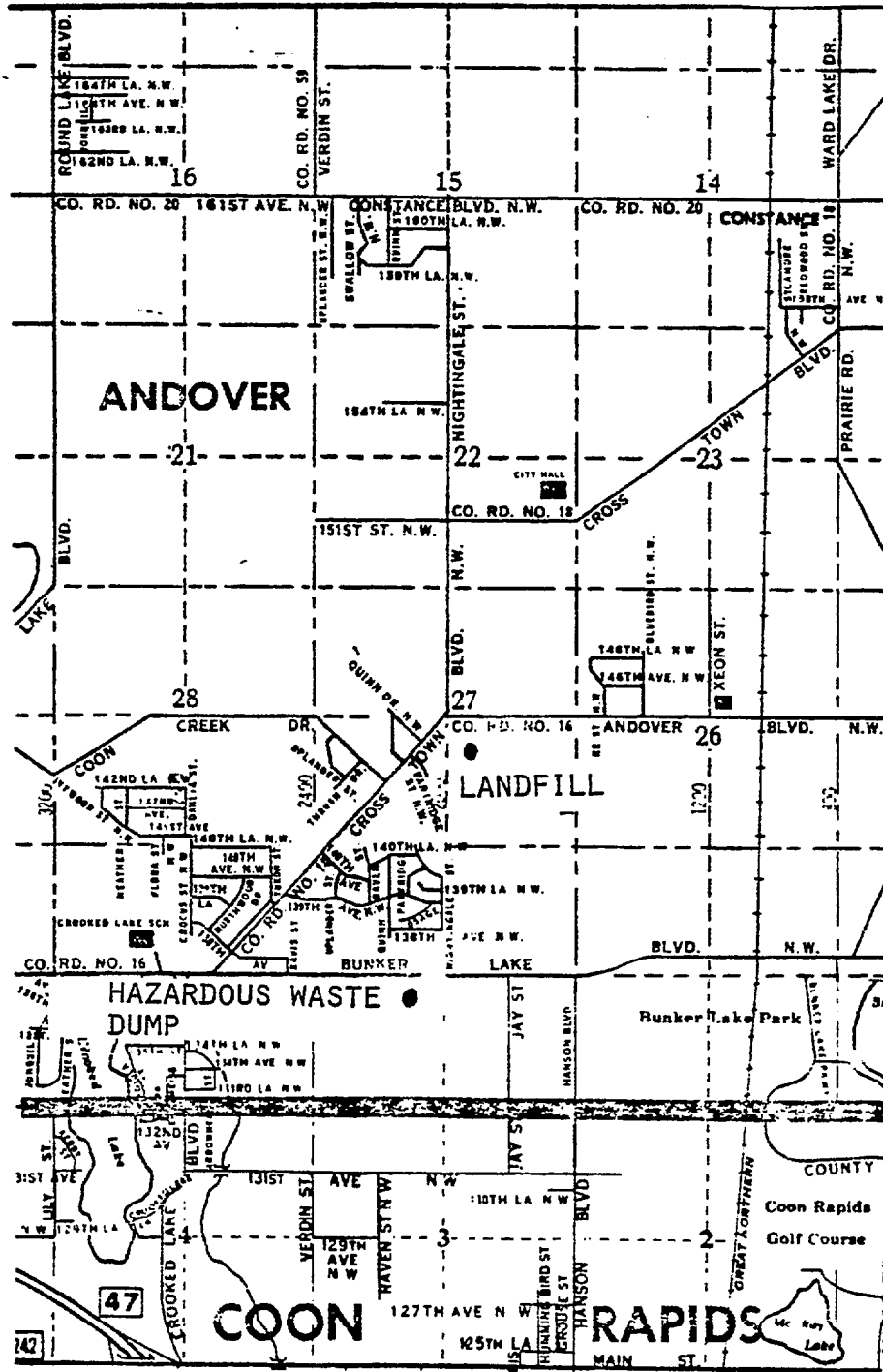
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[10]Bureau of Census, <u>1977 per Capita Money Income Estimates for Counties, Incorported Places, and Selected Minor Civil Divisions in Minnesota.</u>

[11]Metropolitan Council of the Twin Cities Area; figures for 1981.

Map 2

Andover

The waste **site**[12] (owned by a Cecil Heidelberger) is located at
2052 N.W. Bunker Lake Boulevard, in the southern part of Andover (Map **2**).[13]
A second site of interest was also discovered in Andover. This is a munic-
ipal landfill located 1/2 mile north of the hazardous waste site next to
Coon Creek where, many years ago, hazardous waste was buried in an asphalt-
lined pit, the lining of which has now begun to deteriorate.

The Andover site fulfills the site selection criteria for the most
part. There is a continuous, fairly homogeneous suburban population
around the site, and there is some evidence of public knowledge of the
contamination incident. Unlike Pleasant Plains, however, the Andover
site was chosen because it is an example of a site for which there was
more of a threat of further contamination than actual contamination at
the time of the study. Only 3 wells had been found to be contaminated
and all were located on the Heidelberger property. Also, the nature of
this threat was not known at the time the observed sales took place.
It was thought likely that a property value effect might result
from the potentially substantial costs involved in introducing a municipal
water system in this area, if this proved to be necessary. The expected
incidence of the costs would likely influence property values if they
were expected to fall on the individual property owners. However, since

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[12]**The** site received many barrels of waste solvents, paints, inks, glues,
and grease since 1973, and many of the barrels had deteriorated and had
begun to leak before they were removed.

[13]**The** southerly location of the dump and the fact that the northern part
of Andover is sparsely populated necessitated the inclusion of another
juridiction. The two cities for which data were collected, therefore,
were Andover and Coon Rapids (population 36,660 in 1981).

contamination is largely a threat rather than an actuality, and owners have not yet had to face the possibility of paying for a correction to the municipal water supply, property value effects may be expected to be relatively small.

So, it isn't worth doing more with the Andover site.

IV. THE METHODOLOGY FOR ESTIMATING PRICE EFFECTS AND TESTING THE
     HYPOTHESIS

This section sets forth the method by which the price effects gene-
rated by a hazardous waste site were measured empirically. Testable
hypotheses are developed for the two chosen sites.

The methodology used in this study has been developed and described
in some detail in Chapter II and Appendix A, where it is pointed out
that distance to a dump site or the existence of contaminated private
wells may provide a reliable proxy for measuring the effects produced by
a hazardous waste site. The methodology used to test these hypotheses
formally is a cross-section regression of the sales price for individual
properties on the characteristics of the properties including housing and
neighborhood characteristics, environmental parameters not related to
the site, and other locational attributes.

Two cross-section studies of property values, one before and one
after the siting of a facility or the discovery of contamination, should
be superior to a single cross-section equation. Under this approach the
pre-site/pre-contamination price gradient (change in price with distance)
may be compared with a post-site/post-contamination gradient to show
impacts at various distances from the site. Differences between the
gradients may be reasonably imputed to the siting of the waste facility
or to the discovery of contamination, as the case may be. A price
gradient produced by a single cross-section analysis after the event, on
the other hand, may be more difficult to interpret. (There may be factors
unaccounted for by the model which may produce or obscure a gradient.)

It is realized that linear distance alone may not be sufficient to
describe the important relationships. The association between the source

of contamination and impacts on property value need not be linear. Also,

contamination does not move at the same speed in all directions. This

means that points equidistant from the contamination source are not

expected to generate the same price effects. Thus, ideally the direction

of underground movement of water in the aquifer should also be considered

where there is water pollution. The direction of the wind should likewise

be considered where there is air pollution. *This is what Dr. Anderson wanted to examine using hopethermal for a given price.*

The Pleasant Plains and Andover sites provide an opportunity to test

the effect of waste sites on surrounding property values. In general

terms, the basic hypothesis for both sites is that the known existence of

the hazardous waste site and the known effects generated by them had a

depressing effect on property values. In both cases the dump existed but

was relatively unknown before the **contamination** incident. Thus, it is

difficult to separate the effects generated by the contamination episode

from the disamenity effects of a well publicized dump site. The widespread

evidence of contamination in Pleasant Plains, nevertheless, suggests a

more specific hypothesis in this case. Since contamination was the

principal disamenity and there were no expected negative aesthetic effects,

it is presumed that contamination was the principal problem in Pleasant

Plains. *There also may be an effect from locating a potentially risky HW site...*

The differences between the two sites also potentially provide fur-

ther insight into the behavioral responses to the incident and the ultimate

price effect. For example, the Andover site mainly represents a threat

to private well contamination, while the Pleasant Plains site had actual

widespread contamination of private wells. Thus, it is possible to test

indirectly the notion that people respond more to actual contamination

than to the threat of it.

The Pleasant Plains site also potentially offers an opportunity to ascertain whether contamination of private wells in an area offers a better measure for the disamenity effects than distance from the known source of contamination.

The existence of contamination was reported in a New Jersey EPA report in which official zones of contamination were **defined.**[14] In scrutinizing the evidence on contamination in Pleasant Plains, it became apparent that the identified zones were not entirely reliable. There had been evidence during the months following the first discovery of contamination that some wells outside the specified zones were contaminated, that monitoring results varied from day to day inside the zone and that some wells inside the zone were not known to be contaminated.

In view of the controversy surrounding the interpretation of the monitoring results, it was not possible to test the proposition that people responded to contamination of their individual wells per se. Rather, only the hypothesis that people responded to the officially designated zone of contamination was tested.

For the Pleasant Plains site, analysis is based on two distinct models, each applied to two different samples. Model I represents the waste site as discrete distance measurements; whereas in Model II the designated contamination zone is used as a proxy for the dump. Delineation of the samples was simply on the basis of pre-1974 and post-1974 sales. In contrast, Andover is represented by one sample and a single model.

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[14]U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Final Report - Analysis of a Land Disposal Damage Incident Involving Hazardous Waste Materials, Dover Township, New Jersey, by M. Ghassemi, (Redondo Beach, CA: TRW Systems Group, May 1976).

Denoting the general form of the vector of housing and lot characteristics by X, the locational characteristics by Y and the variables denoting date of sale by T, the price model is specified in general terms as follows:

Model 1 $LPV = a + bX + cY + dT + eD + u$

where D is the variable or set of variables representing distance from the dump and LPV is the sales price of each house, specified in log form. Some house characteristics, such as house size and lot size, were also specified in log form for the two sites.

The data from both sites for the period after contamination was discovered were applied in a cross-section analysis of housing prices in an area of approximately a 2 1/2 mile radius from the waste sites using the model described above. The variable D, representing distance from the dump, was used as a proxy for the intensity of contamination. It was hypothesized that house prices, _ceteris_ _paribus_, would increase with distance from the source of contamination, but that at some distance they would approach the equilibrium value of houses that are located far from the site. The relationship between distance and prices, therefore, was not expected to be linear. The data are consistent with the hypothesis; the test of this hypothesis is that the price gradient is statistically significant in the Pleasant Plains case.

In order to test the hypothesis that the gradient before the incident was different from that after it, the Pleasant Plains data were divided into pre- and post- 1974 sales. It was considered possible, using this

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[15]The first contaminated well was discovered approximately 2 years after the illegal dumping operation had commenced. This event, which precipitated public awareness of the illegal dumping, would also be measured by the method described above.

approach, to isolate the effect of the contamination episode itself.[15]

A price gradient measured prior to contamination was expected to provide

information on the effects potentially generated by any other disamenities

in the area prior to the contamination episode. Comparison with a post-

contamination price gradient should demonstrate that what is actually

being measured is the effect of contamination on price.[16] The effects

on price of being within the identified zones of contamination (Zone I

and Zone II)[17] were also tested in a second model (Model II). Instead

of distance dummy variables, indicators were used for whether the property

was in the contaminated zone:

Model II   LPV = a + bX + cY + dT + eZ + u

where Z represents the contaminated zone.

Data on all of the recorded housing sales for both sites were obtained

from the respective county assessment offices, for the period from the

third quarter in 1968 to the last quarter in 1981 for Pleasant Plains,

and from the second quarter of 1978 to the last quarter of 1981 for

Andover. For each sale, data were obtained from the assessment cards on

characteristics of the home and lot. Sample sizes were 250 in Andover

and 675 for the combined Pleasant Plains samples. The date of transfer

of the deed was entered by quarter as an individual independent variable.

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[16]Two assumptions need to be made in order to interpret the results of such a study, i.e., that there are no significant changes in tastes during this period and that residents were not affected by the presence of any co-located negative externalties before, compared with after the contamination experience.

[17]Two contamination zones were identified. Zone I represents the area in which wells were ordered to be capped and the municipal water supply introduced. Zone II represents the area in which deeper wells were ordered to be dug. Not all wells were found to be contaminated in Zone II.

The time variable is expected to capture the effect of general price level changes as well as any other factors that change over time such as interest **rates.**[18] A set of site specific variables was also included to reflect the location of individual properties relative to other dis-amenties and amenities in each area. Detailed socio-economic information for individual neighborhoods was not available. However, population density (person per room) and housing density (houses per acre) were available as a proxy for neighborhood socio-economic status.

Non-linear and linear specifications of the variables showing distance from the waste **sites were** tested in both Pleasant Plains samples. In addition, in order to observe how property values change with changes in distance from the sites, a set of distance dummy variables was constructed to present the information in very general terms.

The distance dummy variables and distance specified as a simple linear term were expected to have positive signs. The non-linear quadratric squared term **(D^2)** and the reciprocal term $\frac{1}{D}$ were expected to have negative signs. In the latter case property values were expected to rise steeply at first then asymptotically approach the equilibrium price level away from the site.

In a quadratic specification the distance effect could be either "U" shaped or "inverted "U" shaped, neither of which is supported by our prior reasoning. The contamination variable in the second model using zones was expected to have a negative sign. This is because the contami-nated area is expected to be negatively correlated with property values.

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[18]An alternative way of specifying price level changes was with a linear trend. However, it was not considered reasonable to assume that these changes would be necessarily linear.

The expected signs of the coefficients associated with housing character-
istics are positive except, in some cases, where they are dummy variables.
For the latter case, in the Pleasant Plains samples, a zero value is
given where there is a feature such as a basement or fireplace, and a
value of 1 given where there is not. The coefficients are, therefore,
expected to be negative. The reverse is true for Andover. The sales
date dummy variables are expected to have positive coefficients, because
of general inflation over the period.

The expected signs for individual neighborhood variables are discus-
sed along with the results in the next section.

V.   RESULTS

The regression results are presented in Tables 1 and 2 for the Pleasant Plains samples and in Table 3 for the Andover sample.

The final equations presented and discussed below are the results of extensive careful empirical analyses and statistical tests. The steps undertaken to produce the preferred descriptive model and to test the hypotheses of this study are described primarily in Appendix C. In total, 27 equations are presented for the Pleasant Plains samples and 11 for the Andover sample.

A.   Pleasant Plains

Table 1 presents the results of the pre-1974 sample and the post-1974 sample run separately both using Model 1 (where distance is used as a proxy for the effects of the dump). Table 2 presents the results of the combined sample using Model 2 (where contamination zones are used as a proxy for the effects of the dump). The equations underlying these tables are in semi-log form; consequently, the coefficients shown in the table can be interpreted as showing the percentage change in price associated with each. Equation 1, sample 1, seems to provide the best results for Model 1 both in terms of goodness of fit (R^2) and in terms of statistical significance for the individual variables (F Statistic), including the variables representing distance from the waste site.

In equation 1, sample 1, distance from the waste site was specified as eleven 1/4 mile dummy variables.[19] A gradient plotted with the coefficients of the individual quarter mile dummy variables is presented in Figure 2. This gradient indicates in general terms that property values

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[19]Each dummy represents the observations inside eleven concentric circles-- each 1/4 mile apart.

Table 1

Pleasant Plains Regression Results for Sample 1 and Sample 2

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)	
	Equation-1, Sample 1 Post-1974 Data	Equation 1, Sample 2 Pre-1974 Data

Variables[1]

Constant	1.599595	2.408774

Neighborhood Variables

Natural Log of Distance from Central Business District (In Miles)	.0776899* (.03328)	-.0291194 (.06349)
Distance from the Garden State Parkway (In Miles)	.1053314* (.03978)	.0028489 (.10052)
Distance from the Access to the Parkway (In Miles)	-.0604575 (.05155)	.0145000 (.01665)
Distance to the High School[2]	**-.1984953*** **(.08165)**	**-.6455401*** **(.23675)**
Distance to the Hazardous Waste Source (In Miles)	**See Figure 4**	**See Figure 5**
Average No. of Rooms Per Person According to Enumeration District	.1119172* (.05452)	.0432376 (.10398)

*An indication of the coefficients which are statistically significant at the 95% level.

[1] A full description of the variables is given in Appendix C.

[2] This variable was trended so that all residences within 1/4 mile were given the value .25, within 1/2 mile .5 and outside 1/2 mile 1.

Table 1 (continued)

Pleasant Plains Regression Results for Sample 1 and Sample 2

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)	
	Equation 1, Sample 1 - Post-1974 Data	Equation 1, Sample 2 Pre-1974 Data

Variables

House Characteristics

Age	-.(1013026 (.00068)	.00102944 (.00157)
Natural Log of House Area (in sq. feet)	.2977651* (-03635)	.1931030* (.07401)
Basement (1 if no basement)	-.0449415* (.01378)	.0332259 (.03648)
Air conditioning (1 if no air conditioning)	-.0485741* (.01251)	-.0889687* (.02898)
Fireplace (1 if no fireplace)	-.0549834* (.01455)	-.0639212 (.04498)
Bathroom Fixtures	.0521778* (.01524)	.1331987* (.04538)
Garage (A) if no garage	**	**
Garage (B) (1 if 1 garage)	.0689773* (.026321)	.1659923* (.06327)
Garage (C) (1 if 2 garages)	.0816214* (.02746)	.2102363* (.07120)
Garage (D) (1 if 3 or more garages)	.0535160 (.06474)	.3786271* (.13270)

*An indication of the coefficients which are statistically significant
 at the 95% level.

**Ommitted dummy.

Table 1 (continued)

Pleasant Plains Regression Results for Sample 1 and Sample 2

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)	
	Equation 1, Sample 1 Post-1974 Data	Equation 1, Sample 2 Pre-1974 Data

Variables

Class of House (Class 4)[3]	-.3982160* (.07293)	-.6588789* (.24716)
Class of House (Class 3)	-.2803524* (.05378)	-.3739844 (.17397)
Class of House (Class 2)	-.0509555 (.04964)	-.1462648 (.15968)
Class of House (Class 1)	**	**
Condition of the House (1 = good, 2 = fair 3 = poor)	-.1797863* (.03219)	-.1801360 (.10958)

Lot Characteristics

Natural Log of Lot Size (In Thousands of Feet)	.05682508* (.01636)	-.0335453 (.04888)
Number of Outbuildings	.0497313* (.02064)	.0814083 (.06956)
Zone A (Rural Residential) Minimum Lot 43,560 sq ft	.1270313* .06086	No Observation
Zone B (Rural Highway Business/Residential/Com-mercial) Minimum Lot 43,560 sq ft	.0530327* (.05504)	.3673595* (.14731)
Zone E (R-150 Residential Zone; not Cluster)	-.02207217 (.02240)	.01815032 (.05227)

*An indication of the coefficients which are statistically significant at the 95% level.

**Ommitted dummy.

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[3]See Appendix C for a full description of this variable.

Table 1 (continued)

Pleasant Plains Regression Results for Sample 1 and Sample 2

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)	
	Equation 1, Sample 1 Post-1974 Data	Equation 1, Sample 2 Pre-1974 Data
Variables		
Zone F (Planned Retirement Community) Minimum Lot 5,000 sq ft	-.0805636* (.02867)	-.1019895 (.7984)
Zone J (R-400 Residential Zone) Minimum Lot 45,500 sq ft	.0464310 (.05140)	-.4765513* (.14975)
Zone M (R-120 Residential) Minimum Lot 12,000 sq ft	**	**
Pool (In ground)	.2120923* (.08571)	.0983940 (.11340)
Pool (Vinyl)	.1371651* (.02658)	.0327478 (.05681)
Time Variables		
Sales Date 1/4 Year Dummy Variables **Trended**[4]	.9914428* (.03646)	1.014053* (.07341)
R^2	.90087	.82655
$\bar{R}^2$	.89216	.78811
F	103.40832	21.50507
SE	.11219	.14167

*An indication of the coefficients which are statistically significant at the 95% level.

**Ommitted dummy.

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[4]The individual 1/4 year coefficients of the dummies ran separately were multiplied by their respective dummy values and added so that they took the form of a single continuous variable. This was largely done for the purpose of exposition and did not affect the other coefficients in the equation or the $\bar{R}$2.
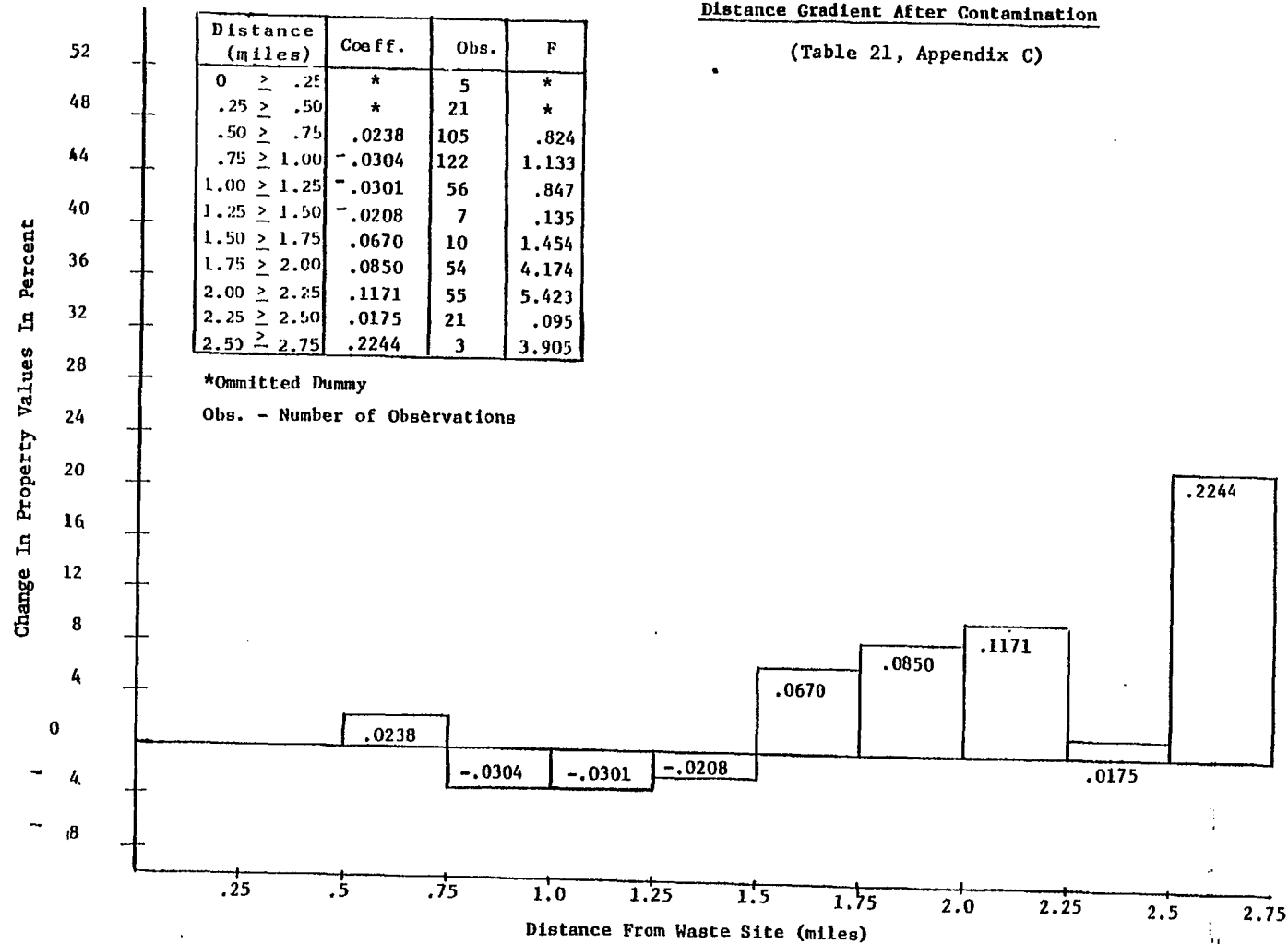
Figure 2

Distance Gradient After Contamination

(Table 21, Appendix C)

Distance (miles)	Coeff.	Obs.	F
0 ≥ .25	*	5	*
.25 ≥ .50	*	21	*
.50 ≥ .75	.0238	105	.824
.75 ≥ 1.00	-.0304	122	1.133
1.00 ≥ 1.25	-.0301	56	.847
1.25 ≥ 1.50	-.0208	7	.135
1.50 ≥ 1.75	.0670	10	1.454
1.75 ≥ 2.00	.0850	54	4.174
2.00 ≥ 2.25	.1171	55	5.423
2.25 ≥ 2.50	.0175	21	.095
2.50 ≥ 2.75	.2244	3	3.905

*Ommitted Dummy

Obs. - Number of Observations

are depressed in the vicinity of the waste site. Residences 1.5 to 1.75 miles from the site sell on average for 6% more than those which are within .5 miles of the site. Also houses that are 2.5 to 2.75 miles away from the site sell on average for 22% more than those that are within a mile.

The results for equation 1, sample 1, also indicate, as expected, positive effects of house size, lot size and assorted living extras such as basements, fireplaces, garages, etc. The time related variables were also highly significant, indicating, as expected, inflationary as well as real price effects in the housing market from year to year. Further, some of the neighborhood variables were also significant and with the predicted signs.

Of neighborhood variables, distance from the Garden State Parkway was significant and with the predicted (positive) sign. This coefficient was expected to capture the nuisance effect of being close to a busy highway. Distance from the access to the parkway, though not significant at the 95% level, also had the predicted sign. The coefficient representing distance from the central business district, Toms River, was positive rather than negative, as is usually hypothesized in the literature. The latter result demonstrates that property values rise in and around Pleasant Plains the further one goes from the central business district, Toms River. This may be due to the fact that for the majority of the observations (located in the south and southwest quadrants of Pleasant Plains) being further from the central business district also means being closer to Pleasant Plains. Anecdotal evidence suggests that

Pleasant Plains is regarded as a better place to live than is downtown Toms River.

While the elementary school did not appear to have any significant effect on house prices,[20] distance from the high school was strongly negatively correlated with house prices. Property values one mile away from the high school were 20% lower than property values nearby. This result suggests that the amenity is important to residents.

Table 1 also describes the results for the sales that occured before the 1974 contamination episode (sample 2) that were tested using the same model (Model 1). Overall, similar results were generated in both samples for the variables describing housing characteristics. However, the neighborhood variables, in particular, were generally insignificant in sample 2 and, furthermore, tended to have unpredicted signs.[21]

There is some evidence that the area underwent some changes during the period of study (from 1968 to 1981). In particular, it became fashionable to live in Pleasant Plains, rather than in downtown Toms River in the early to mid 1970s. This may explain why Distance from the Central Business District (DCBD) has the predicted (negative) sign for the "before" sample, and an unpredicted positive sign for the "after" sample.[22]

In accordance with the hypothesis, the waste site dummy variables for the pre-1974 sample are statistically insignificant. This means

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[20]This was established in earlier runs, not reported in the tables.

[21]Other exceptions were lot size, which had the wrong sign, and fireplace and basement, which were insignificant. Some zone variables also had different signs in sample 2. Also, the model fit sample 1 better than sample 2.

[22]This result has to be interpreted cautiously. There appeared to be a problem of multicollinearity among the neighborhood variables, particularly in sample 2. It is possible that this could account for the different sign.

that the price gradient for this sample is not, in statistical terms, significantly different from zero (See Figure 3). Further, it can be observed from Figure 3 that the coefficients do not suggest any consistent pattern. This means that house prices do not appear to be affected by distance from the waste site. While the problem of multicollinearity evident in sample 2 suggests that these results may not be entirely reliable,[23] the above provides support for the proposition that, in the absence of contamination, the specific location which later produced the disamenity had no depressing impact on house prices.

The results for the pre-1974 sample (Sample 2) may be contrasted with those for the post-1974 sample (Sample 1) briefly described earlier. For sample 1, a positive and statistically significant gradient that rises fairly consistently after 1.5 miles from the waste site was observed. Further, from 1.75 to 2.25 miles and after 2.5 miles, the coefficients on the dummy variables are statistically significant at the 95% confidence level. The results generated by the "after" sample (Sample 1), therefore, also support our prior hypothesis.

The gradient observed for sample 1 also suggests some specific features of interest. First, the distance at which the coefficients are positive and statistically different from zero corresponds to the periphery of the contaminated zone in the southern and eastern quadrants of Pleasant Plains. This suggests that the distance variable is picking up some of the contamination effect.[24] It may also be noted that property values are

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[23]See footnote 22.

[24]This is particularly likely because the southern periphery appears, from the available evidence, to be a more reliable border of contamination.
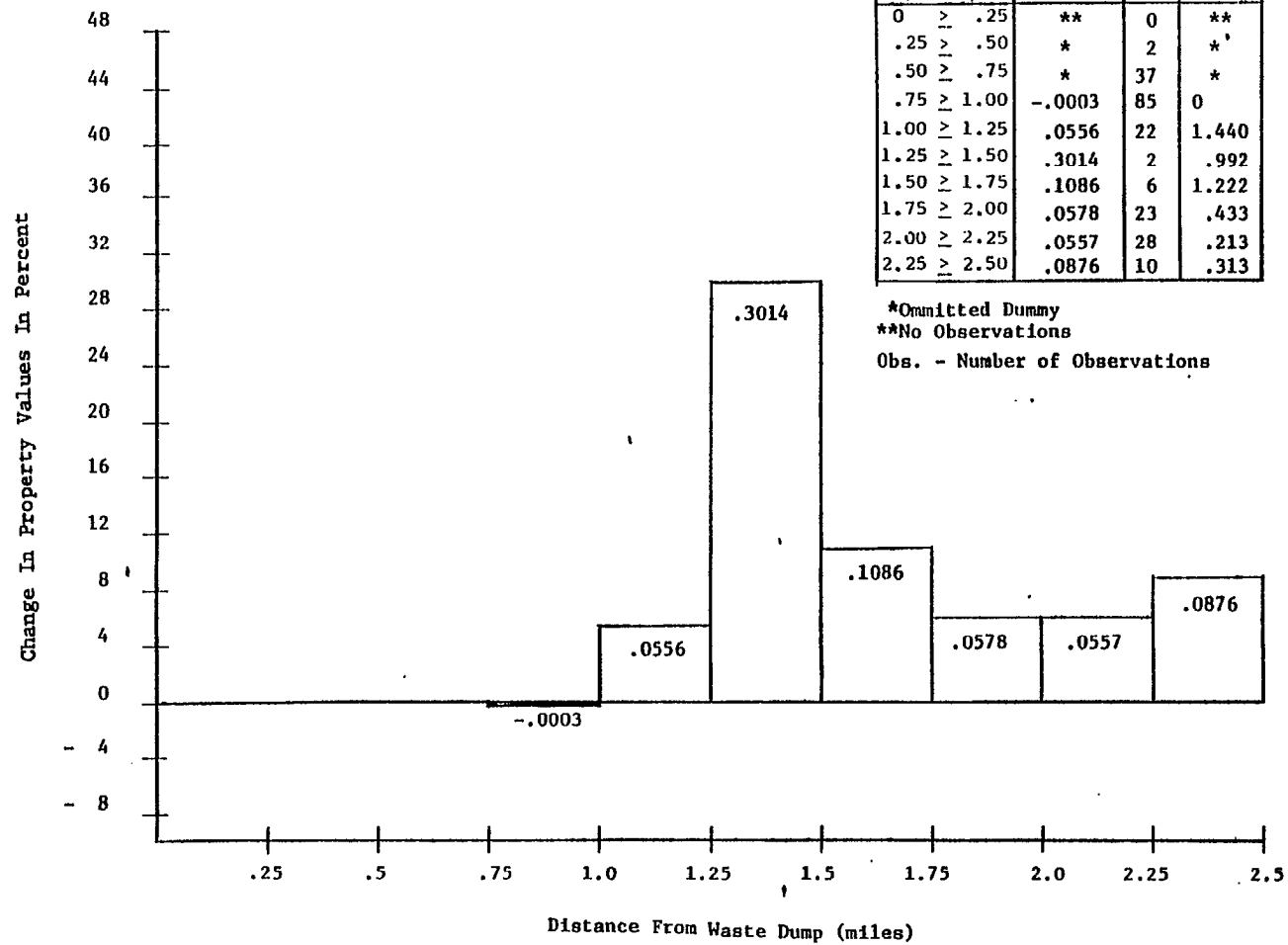
Figure 3

Distance Gradient Before Contamination

(Table 26, Appendix C)

Distance (miles)	Coeff.	Obs.	F
0 ≥ .25	**	0	**
.25 ≥ .50	*	2	*
.50 ≥ .75	*	37	*
.75 ≥ 1.00	−.0003	85	0
1.00 ≥ 1.25	.0556	22	1.440
1.25 ≥ 1.50	.3014	2	.992
1.50 ≥ 1.75	.1086	6	1.222
1.75 ≥ 2.00	.0578	23	.433
2.00 ≥ 2.25	.0557	28	.213
2.25 ≥ 2.50	.0876	10	.313

*Ommitted Dummy
**No Observations

Obs. - Number of Observations

Change In Property Values In Percent

.3014

.1086

.0876

.0556

.0578   .0557

−.0003

.25   .5   .75   1.0   1.25   1.5   1.75   2.0   2.25   2.5

Distance From Waste Dump (miles)

44

relatively higher around the 1 to 1 1/2 mile mark for sample 2 than for
sample 1. This suggests that the dump may have had a dampening effect
on house values after 1974 at this distance.

Several other specifications were used to test the property value
effects of the waste dump with respect to distance. A detailed descrip-
tion of these are presented in Appendix C. Briefly, the reciprocal
transformation with and without a linear term was found to be insignificant.
The double log version of the distance variable was also statistically
insignificant and with the "wrong" sign.

The two demarcated contamination **zones**[25] were tested in various
ways to determine whether they were useful for identifying the effects of
contamination. One of these tests was with a combined pre-1974 and post-
1974 sample, the result of which is presented in Table 2. The results
of this and other tests demonstrated fairly conclusively that the contamin-
ation zones designated by the New Jersey Environmental Protection Agency
may not be reliable indicators of the contamination problem. As evidenced
by the coefficients for the variables, "contamination I" and "contamination
II," properties situated inside the contamination zones seem to be higher
in value (than those outside), rather than lower. This result does not
correspond to the prior hypothesis but may be attributed to the unreli-
ability of the contamination zone designations.

Moreover, there is reason to believe that the contaminated zone
variable can not be independently specified. This is because the boundary
of Pleasant Plains corresponds to the outer boundary of contamination

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[25]**Zone** 1 corresponds to the area in which the households were ordered to
seal their wells. Zones II corresponds to the area in which the households
were ordered to dig deeper wells.

Table 2

Pleasant Plains Regression Results for Combined Sample
Using Contaminated Zones

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)
Variables	
Constant	
Neighborhood Variables	
Log of Distance from Central Business District (In Miles)	-.02878951 (.02106)
Distance from the Garden State Parkway (In Miles)	.0343608 (.03800)
Distance from the Access to the Parkway (In Miles)	.0491057 (.02999)
Distance to the High School[1]	-.2115232* (08399)
Contamination Zone I (If Inside Zone--after Jan. 1974)	.0652184 (.03773)
Contamination Zone II (If Inside Zone--before Jan. 1974)	.0286988 (.02207)
Average Rooms per Person According to Enumeration District	.0280148 (.04687)

*An indication of the coefficients which are statistically significant at the 95% level.

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[1]This variable was trended so that all residences within a quarter of a mile were given the value .25, within a half mile .5 and outside a half mile 1.

Table 2 (continued)

Pleasant Plains Regression Results for Combined Sample
Using Contamination Zones

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)

Variables

House Characteristics

Age	.0014726* (.00067)
Natural Log of House Area (in sq. feet)	.3089936* (.03561)
Basement (1, if no basement)	-.0291957 (.01465)
Air conditioning (1, if no air conditioning)	-.0465765* (.01310)
Fireplace (1, if no fireplace)	-.0545352* (.01598)
Bathroom Fixtures	.0662329* (.01625)
Garage A (1, if no garage)	**
Garage (1, if 1 garage)	.0605540* (.02731)
Garage Number (1, if 2 garages)	.0878687* (.02880)
Garage Number (1, if 3 or more garages)	.0933383 (.06465)
Class of House (Class 4)	-.4652950* (.08066)
Class of House (Class 3)	-.2965931* (.05947)

*An indication of the coefficients which are statistically significant at the 95% level.

**Ommitted dummy.

Table 2 (continued)

Pleasant Plains Regression Results for Combined Sample
Using Contamination Zones

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)
Variables	
Class of House (Class 2)	-.1023078 (.05548)
Class of House (Class 1)	**
Condition of the House (1 = good, 2 = fair, 3 = poor)	-.1835900* (.03392)
Lot Characteristics	
Natural Log of Lot Size (In Thousands of Feet)	.0697358* (.01687)
Number of Outbuildings	.0481351* (.02106)
Zone A (Rural Residential) Minimum Lot 43,560 sq ft	-.0112230 (.05195)
Zone B (Rural Highway Business/Residential/Commercial) Minimum Lot 43,560 sq ft	.04116878 (.05734)
Zone E R-150 (Residential Zone; not Cluster)	-.0014164 (.02621)
Zone F (Planned Retirement Community) Minimum Lot 5,000 sq ft	-.0339311 (.03560)
Zone J (R-400 Residential Zone) Minimum Lot 45,500 sq ft	-.0599618 (.05394)
Zone M (R-120 Residential) Minimum Lot 12,000 sq ft	**

*An indication of the coefficients which are statistically significant at
the 95% level.

**Ommitted dummy.

Table 2 (continued)

Pleasant Plains Regression Results for Combined Sample
Using Contamination Zones

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)
Variables	
Pool (In ground)	.0870860 (.07047)
Pool (Vinyl)	.0880807* (.02736)
Time Variables**	
R^2	l 92155
$\bar{R}^2$	.91068
F	84.80691
SE	.13263

*An indication of the coefficients which are statistically significant at the 95% level.

**See Appendix C for the results of the full list of sales variables.

zone II, and there is evidence that Pleasant Plains is more highly valued for unrelated reasons than the area outside. Therefore, a negative effect on prices, brought about by contamination, may have been offset by the positive value of living in Pleasant Plains. This latter effect cannot easily be controlled by the model.

B. Andover

The results for the Andover sample are presented in Table 3. In contrast to the Pleasant Plains results for the equivalent sample (after the discovery of contamination), the dump variable when expressed as a single linear term was insignificant and had an unpredicted sign. In addition, distance from the other waste site in the area, the landfill, carried the correct sign, but was insignificant. Property values were expected to be positively correlated with distance from the waste dump. **However, the negative sign of its coefficient indicates that the existence of contamination had triggered no decline in property values.**

Despite the failure to show significant results as a function of distance from the waste site, the Andover model appears to be well designed, because it produces appropriate findings on other variables. As shown in Table 3, the results for the Andover sample were similiar to those of Pleasant Plains, with regard to housing characteristics such as ground-floor **area**[26] fireplace and housing styles. Ground floor area, which carried the expected sign as well as being very significant, indicates that an increase of 1% in ground floor area generates approximately a 0.5 %

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[26]**The** log of GFA was used in order to capture suspected decreasing returns to scale associated with the variable. However, this specification did not visibly improve its explanatory power.

<u>Table 3</u>

<u>Andover Regression Results</u>

Dependent Variable Natural Log of Property Values	Regression Coefficient -(Standard Error)

Variables[1]

Constant	.7694669

<u>Neighborhood Variables</u>

Distance from Bunker Bill Outside 1.5 miles	-.1014969* (.04512)
(Recreation Site) Distance from Crooked Lake Elementary (In Miles)	.0140567 (.04820)
Distance from Washington Elementary (In Miles)	-.0605006 (.09894)
Distance from Wilson Elementary (In Miles)	-.0600659 (.04404)
Distance from Roosevelt Junior High (In Miles)	-1193512* (.05514)
Distance from Main Highway into Minneapolis (In Miles)	-.0155210 (.02952)
Distance from Central Business District (In Miles)	-.0105190 (.02164)
Distance from the Waste Site (In Miles)	-.0505798 (.04462)
Distance from the Landfill (In Miles)	.0414750 (.04427)
Lake View (In Miles)	-.1020730* (.04164)

[1]**See** Appendix C for a full description of the variables.

*Coefficients that are significant at the 95% level.

Table 3 (continued)

Andover Regression Results

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)
Variables	
House Characteristics	
Age	-.00668238* (.00132)
Natural Log of Ground Floor Area (sq ft)	.5003685* (.06560)
Number of Bedrooms	.0384741* (.01162)
One and One Quarter Stories (Housing Style)	-.2993583* (.08669)
One and One Half Stories (Housing Style)	-.3947195 * (.16048)
Rambler (Housing Style)	-.3150149* (.05374)
Split Entry (Housing Style)	-.2735871* (.05380)
Split Level (Housing Style)	-.2640650* (.06143)
Two Stories (Housing Style)	**
Fireplace (1 if yes)	.0453648* (.02019)
Lot Characteristic	
Lot Size (in thousands of feet)	.0009444 (.00053)

*Coefficients that are significant at the 95% level.

**Ommitted dummy

Table 3 (continued)

Andover Regression Results

Dependent Variable Natural Log of Property Values	Regression Coefficient (Standard Error)
Variables	
Time Variables	
Sale Date Dummy **Trend**[1]	.9608067* (.11568)
R^2	.68967
$\bar{R}^2$	.65604
F	20.50652
SE	.11622

*Coefficients that are significant at the 95% level.

---

[1] **Individual** 1/4 year dummies were trended to produce a single value, as in the Pleasant Plains sample.

increase in property values. Two-story **homes**[27] appear to be the most

valuable type of housing, priced at approximately 40% more than the

next preferred one and one-half story structure. As expected, residents

place a high value on proximity to the lake and are, therefore, willing to

pay a premium of 10% in order to have a view of the lake. The coefficient

associated with a garage has the predicted sign but was unexpectedly

insignificant. Especially in light of the subzero temperatures often

experienced in Minnesota, this is suprising. In addition, lot size

was **insignificant.**[28]

The sale date **trend**[29] was the most significant variable and also had

the expected sign. Neighborhood characteristics were statistically

insignificant,[30] except distance from Roosevelt Junior High School. This

variable along with distance from Washington Elementary School carried

unpredicted signs. Further, the central business district as well as

all the other variables carried the predicted signs.

The fact that the results do not indicate that the dump and landfill

are environmental disamenities is contrary to prior hypotheses and demands

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[27]**The** ommitted dummy.

[28]**Lot** sizes (LSZ) that exceeded 2.5 acres were deleted from the sample
to reduce the effect of potential subdivision and future development. As
a result, the sample size was reduced by 21 observations. The variation
in LSZ was reduced, probably causing the variable to be insignificant.
It had been significant in previous runs when the larger lots were left in.

[29]**The** sale date variable was trended in the same way as in the Pleasant
Plains model.

[30]**The** presence of the waste dump variable in the equation is the likely
explanation for the relative insignificance of the neighborhood variables.
These variables have all co-existed at high levels of significance in
prior specifications. (See Appendix C, Table 30.)

further explanation. Early analysis of the two disamenity variables
demonstrated that there was a problem of multicollinearity between them.
This is borne out by a correlation coefficient of .84184 for the equation
described in Table 3. The correlation matrix also indicated high
collinearity among the neighborhood variables as well as between the
neighborhood variables and the waste dump and landfill.

Several efforts were made to isolate the effect of the waste site on
land values. For example, two separate models were formulated to distin-
guish the effects of the waste site and the landfill from neighborhood
amenities and/or disamenities. All neighborhood variables were included
in the first model (Model A), but all were ommitted from the second (Model
B). Each of these models was tested with different combinations of the
waste site variables. The first equation in each model included the dump;
the second the landfill; and the third, both (see Tables 31-33 and 34-36
in Appendix C).

Comparison of the results from the two models did not suggest that
the model had been originally misspecified. In general, the results
confirm the absence of significant property value changes for the dump
and landfill. Distance from the waste dump and distance from the landfill
were insignificant both with and without neighborhood factors. The
neighborhood variables are, on the other hand, significant when the land-
fill and dump are ommitted from the equation (see Table 30, Appendix C).
This suggests that other neighborhood factors were more important to
property owners and prospective purchasers than were the dump and the
landfill. *This is not surprising given that we were no wealand other poter*

It may be noted that neither distance from the waste dump nor distance from the landfill were specified as a single continuous variable in either of the above mentioned models. Instead, the variables were disaggregated into 1/4 mile dummy variables in order to establish whether a price gradient exists. As Figure 4 indicates, the general tendency (when neighborhood factors are ignored) is for property values to decline as one moves away from the *waste* dump. The decline, however, is not systematic and no equilibrium seems to be approached over the distance observed. For the same model, there was no strong tendency for property values to change as one moved away from the landfill (Figure 5).

As illustrated by Figures 6 and 7, whenever the distance from the waste dump and distance from the landfill dummies are combined in the same equation, some of the dummies associated with each disamenity become significant. However, the significant waste dump dummies are generally beyond the 1.5 mile point, which implies that for the first 1.5 miles away from the dump, changes in property values are not significantly different from zero.

Moreover, when the dump and landfill are entered together, each exhibits a pattern vastly different from that observed when they are entered independently. The general tendency is for property values associated with the dump to decline as distance from the site increases. In contrast, values tend to increase as one moves away from the landfill.

This strange outcome can be attributed to multicollinearity since the proximity of the dump and landfill make it very difficult to separate their individual effects. Indeed, after approximately the first 1/2 mile, the further a property is from the landfill, the further it is from the dump in many parts of the area.

DISTANCE COEFFICIENT FROM
TABLES 34-36 & 33 IN APPENDIX C

FOR FIGURE 4

Distance (miles)	DWD Coeff.	DWD F	Obs.
0 ≥ .25	*	*	4
.25 ≥ .50	-.0521	.485	14
.50 ≥ .75	-.0461	.389	17
.75 ≥ 1.00	-.0542	.568	31
1.00 ≥ 1.25	-.0047	.004	25
1.25 ≥ 1.50	-.0172	.059	28
1.50 ≥ 1.75	-.0760	.790	6
1.75 ≥ 2.00	-.1075	2.150	25
2.00 ≥ 2.25	-.0853	1.353	22
2.25 ≥ 2.50	.0135	.029	12
2.50 ≥ 2.75	-.0497	.379	12
2.75 ≥ 3.00	-.0999	1.780	20
3.00 ≥ 3.25	-.0424	.319	25
3.25 ≥ 3.50	-.0466	.227	5
3.50 ≥ 3.75	**	**	0
3.75 ≥ 4.00	-.2838	3.571	1

FOR FIGURE 5

Distance (miles)	DLF Coeff.	DLF F	Obs.
0 ≥ .25	*	*	3
.25 ≥ .50	-.0615	.692	8
.50 ≥ .75	.0118	.032	15
.75 ≥ 1.00	.0011	0	9
1.00 ≥ 1.25	-.0084	.015	12
1.25 ≥ 1.50	.0654	.866	10
1.50 ≥ 1.75	.0616	.839	13
1.75 ≥ 2.00	-.0434	.465	17
2.00 ≥ 2.25	-.0287	.205	17
2.25 ≥ 2.50	.0517	.600	10
2.50 ≥ 2.75	-.0026	0	1
2.75 ≥ 3.00	**	**	0
3.00 ≥ 3.25	.0011	0	4
3.25 ≥ 3.50	.0298	.089	5
3.50 ≥ 3.75	-.0777	.557	4
3.75 ≥ 4.00	-.0128	.019	7
4.00 ≥ 4.25	.0188	.044	13
4.25 ≥ 4.50	-.0176	.029	18

FOR FIGURE 6

Distance (miles)	DWD Coeff.	DWD F	Obs.	DLF Coeff.	DLF F	Obs.
0 ≥ .25	*	*	4	*	*	3
.25 ≥ .50	-.0639	.710	14	-.0378	.270	8
.50 ≥ .75	-.0755	1.043	17	.0454	.408	15
.75 ≥ 1.00	-.0525	.484	31	.0262	.126	9
1.00 ≥ 1.25	-.0011	.000	25	.0076	.013	12
1.25 ≥ 1.50	-.0980	1.551	28	.1719	5.113	10
1.50 ≥ 1.75	-.1612	2.746	6	.0929	1.934	13
1.75 ≥ 2.00	-.1944	5.314	25	.0692	1.008	17
2.00 ≥ 2.25	-.1554	3.392	22	.0962	1.705	17
2.25 ≥ 2.50	-.0792	.664	12	.1725	5.327	10
2.50 ≥ 2.75	-.0955	1.027	12	.1390	.779	1
2.75 ≥ 3.00	-.1769	4.006	20	**	**	0
3.00 ≥ 3.25	-.1674	3.341	25	.2590	4.336	4
3.25 ≥ 3.50	-.1050	.355	5	.2717	4.173	5
3.50 ≥ 3.75	**	**	0	.1268	1.034	4
3.75 ≥ 4.00	-.5253	7.928	1	.2507	4.851	7
4.00 ≥ 4.25	N.A.	N.A.	N.A.	.2779	5.713	13
4.25 ≥ 4.50	N.A.	N.A.	N.A.	.2038	1.352	18

FOR FIGURE 7

| Distance (miles)	DWD Coeff.	DWD F	Obs.	DLF Coeff.	DLF F	Obs.
0 ≥ .25	*	*	4	*	*	3
.25 ≥ .50	-.0473	.366	14	-.0917	1.486	8
.50 ≥ .75	-.0455	.342	17	-.0063	.007	15
.75 ≥ 1.00	-.0703	.764	31	-.0265	.099	9
1.00 ≥ 1.25	-.0420	.217	25	.0122	.019	12
1.25 ≥ 1.50	-.1667	3.027	28	.1516	2.087	10
1.50 ≥ 1.75	-.2810	4.695	6	.1282	1.291	13
1.75 ≥ 2.00	-.2831	4.078	25	.1812	2.227	17
2.00 ≥ 2.25	-.2643	2.912	22	.2214	2.860	17
2.25 ≥ 2.50	-.1870	1.141	12	.2861	4.023	10
2.50 ≥ 2.75	-.3306	2.469	12	.3877	2.426	1
2.75 ≥ 3.00	-.4222	3.747	20	**	**	0
3.00 ≥ 3.25	-.4490	3.773	25	.2665	.693	4
3.25 ≥ 3.50	-.4289	2.656	5	.2503	.555	5
3.50 ≥ 3.75	**	**	0	.2130	.347	4
3.75 ≥ 4.00	-.4989	1.217	1	.3687	1.056	7
4.00 ≥ 4.25	N.A.	N.A.	N.A.	.4784	1.533	13
4.25 ≥ 4.50	N.A.	N.A.	N.A.	.4423	1.155	18

*Ommitted Dummy
**No Observations
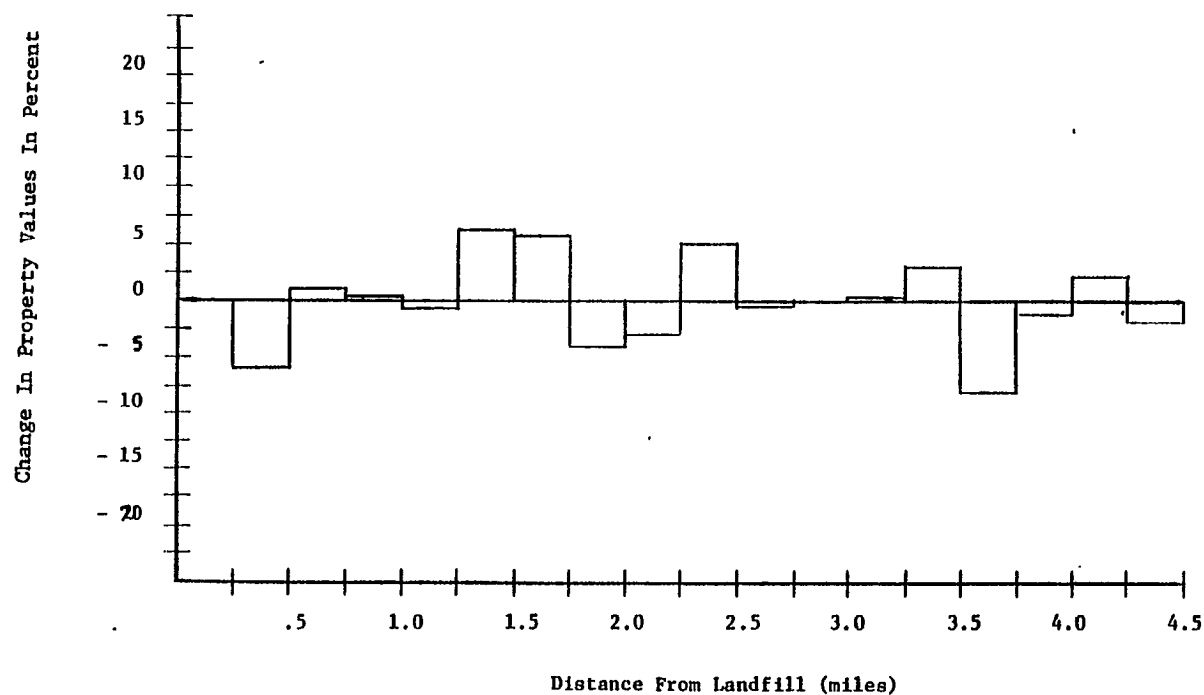Obs. - Number of Observations
N.A. - Not Applicable

Figure 4

Model B:* Distance From the Waste Dump

Without Neighborhood Amenities

(Table 34, Appendix C)
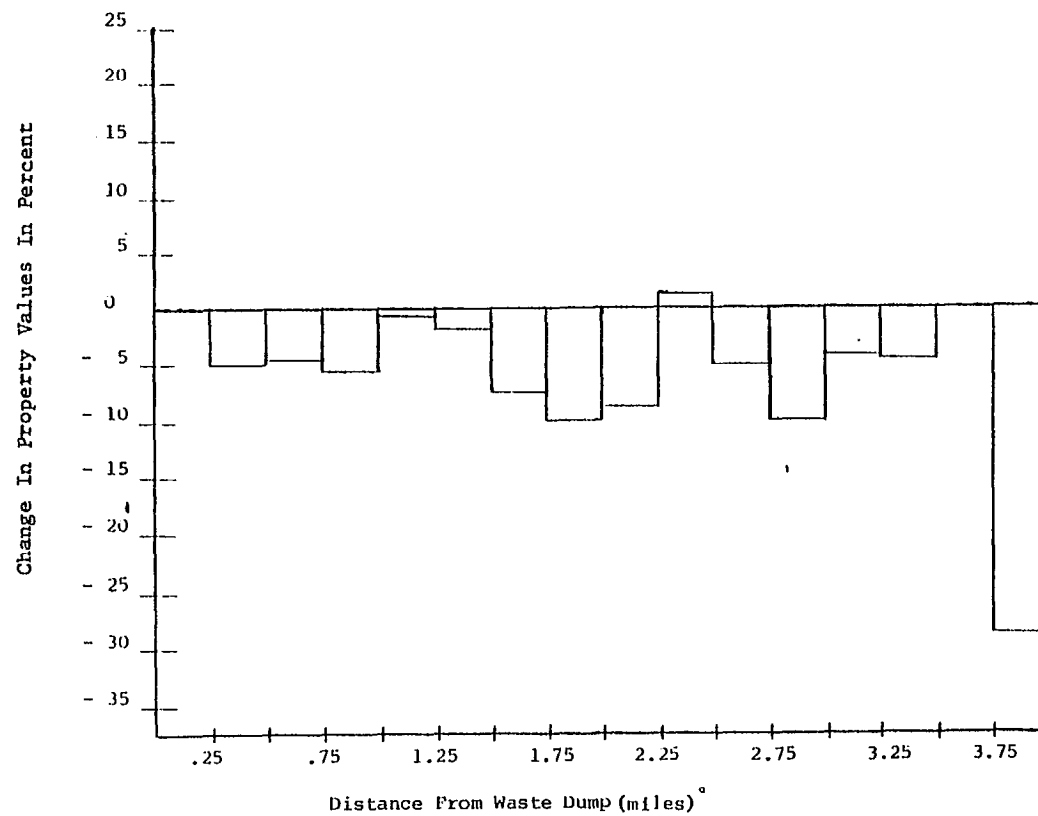
*Model B meets the Specification of Model I described earlier.

Figure 5

Model B:* Distance Prom the Landfill
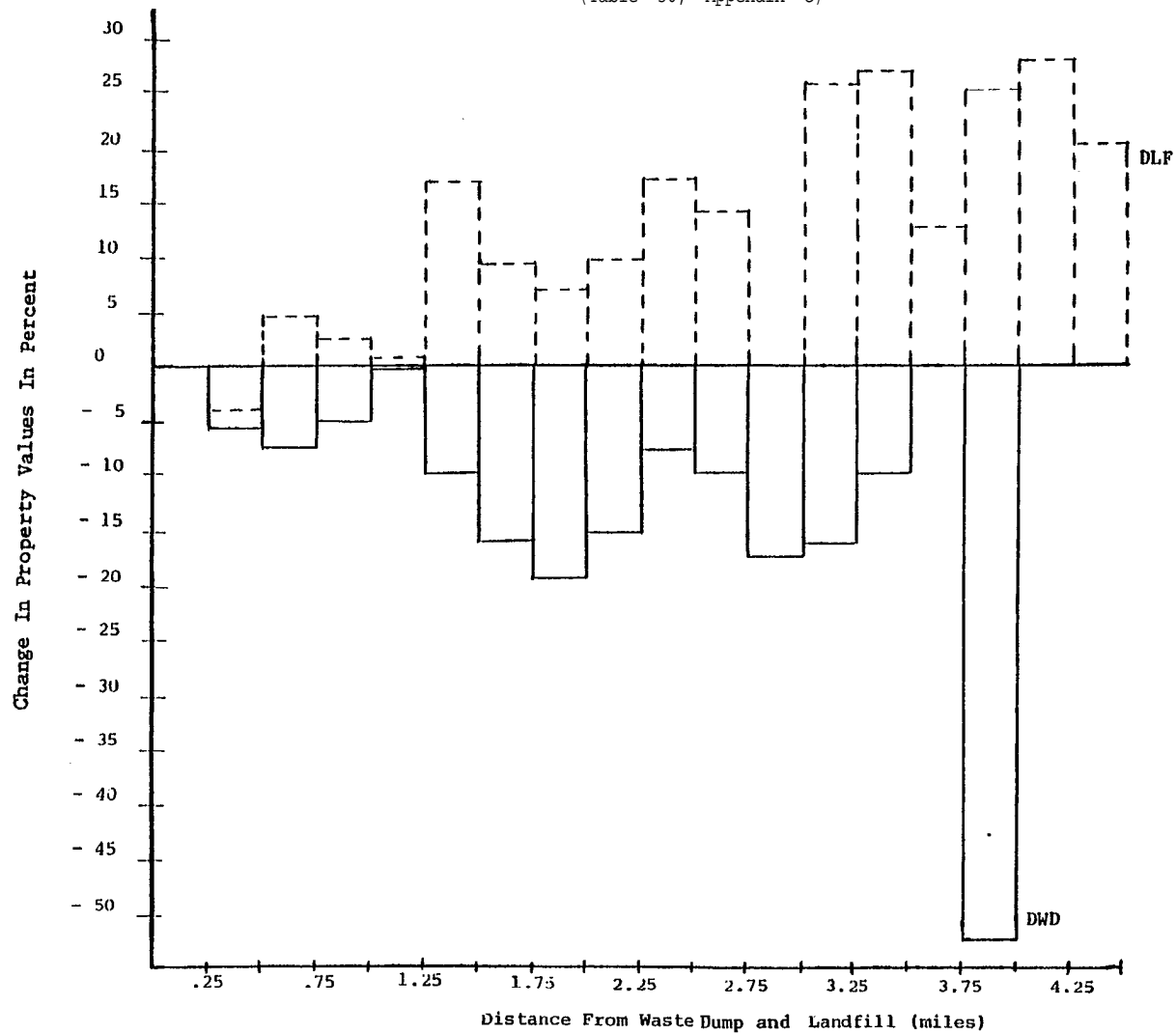Without Neighborhood Amenities

(Table 35, Appendix C)

Distance From Landfill (miles)

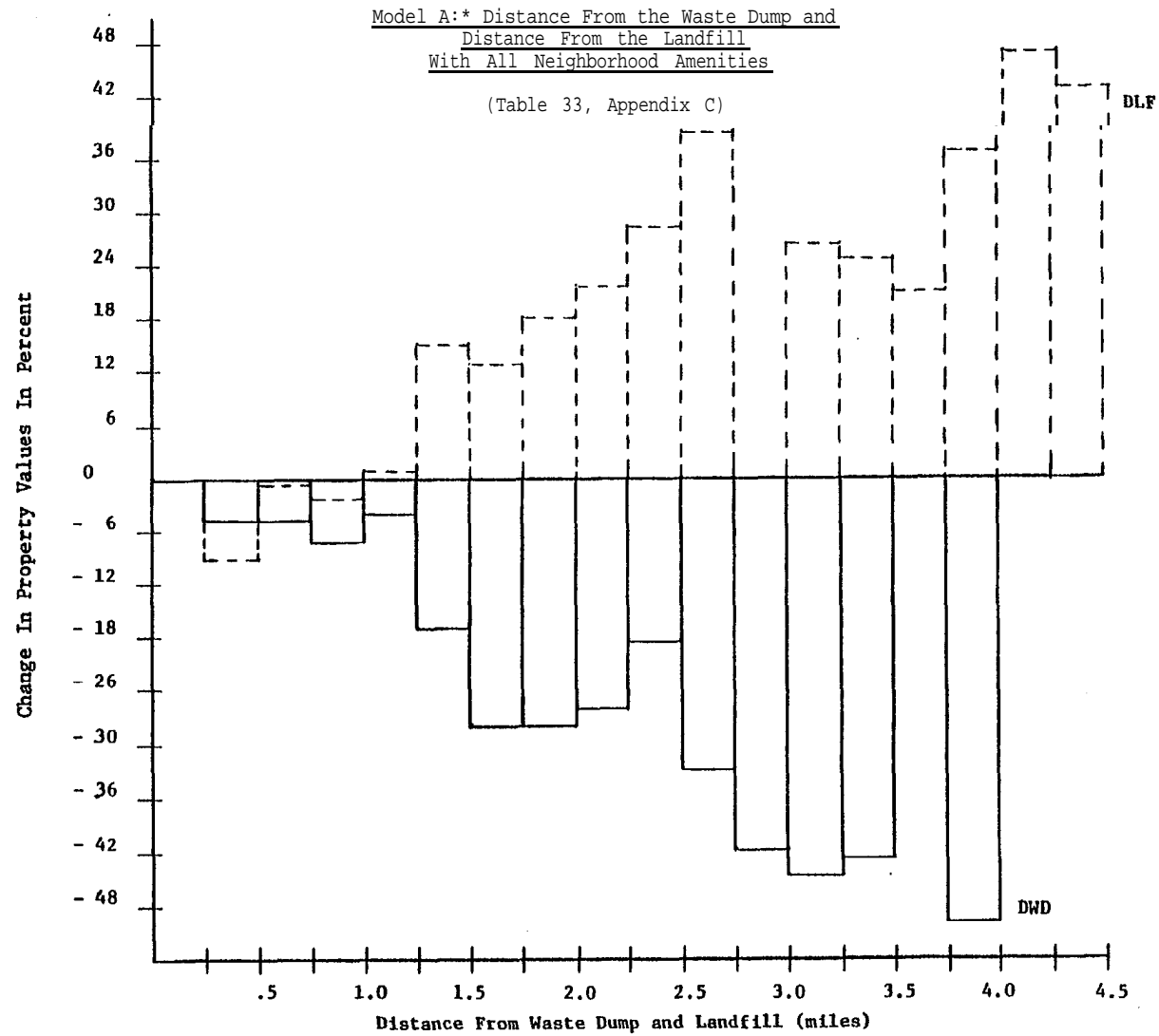*Model B meets the specification of Model I described earlier.

Figure 6

Model B:* Distance From the Waste Dump and Distance From the Landfill Without Neighborhood Amenities

(Table 36, Appendix C)

*Model B meets the specification of Model I described earlier.

Figure 7

Model A:* Distance From the Waste Dump and
Distance From the Landfill
With All Neighborhood Amenities

(Table 33, Appendix C)

*Model A meets the specification of Model I described earlier.